

Proceedings of the Iowa Academy of Science

Volume 57 | Annual Issue

Article 61

1950

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Recommended Citation

Bovee, Eugene Cleveland (1950) "Some Effects of Temperature on the Rates of Embryonic, Postembryonic and Adult Growth in *Hyalella azteca*," *Proceedings of the Iowa Academy of Science*, 57(1), 439-444.

Available at: <https://scholarworks.uni.edu/pias/vol57/iss1/61>

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Some Effects of Temperature on the Rates of Embryonic, Postembryonic and Adult Growth in *Hyalella azteca*

By EUGENE CLEVELAND BOVEE

INTRODUCTION

Although it is generally accepted that temperature is one of the more important factors determining the rate of biological processes for invertebrates, much remains to be investigated concerning its effect on growth and development. Amongst the Crustacea are numerous animals for which such an investigation is practicable. One such organism, readily available in almost any freshwater pond and quite easily raised in the laboratory, is the amphipod *Hyalella azteca*.

HISTORICAL SURVEY

Sexton (1928) presents methods for raising and studying amphipods in the laboratory. In this and other papers (1909, 1924) she gives some effects of temperature on the embryonic and postembryonic rates of development in several species of Gammarus. For *Hyalella azteca* Geisler (1944) presents methods of culture and a comprehensive study of the postembryonic development, and states that temperature is perhaps the most important factor governing the rate of development. She records, however, no data in support of the statement. Gaylor (1922) gives time data for the embryonic and postembryonic developments, but fails to cite the temperatures employed. Embury (1911) and Jackson (1912) also cite time factors for such development, and similarly fail to record temperatures.

MATERIALS AND METHODS

Organisms were obtained from two different sources, Lake McBride, a few miles north of Iowa City, Iowa, and Fisher's Lake, in the Josh Higgins State Park near Cedar Falls, Iowa, by methods previously described (Bovee, 1949). In the laboratory claspings were removed from algal filaments to which they clung and transferred to finger bowls containing filtered lake water from the same source as the organism. A small amount of the alga *Cladophora fracta* was added to each bowl to provide food and shelter. Observations were made three times daily to record the conditions of the embryos, larvae and adults, and the temperatures of waters in the bowls. The bowls were continuously aerated with compressed air. Some of the bowls were kept in a room where, due to

heat absorbed by a roof of wood and asphalt construction, the temperatures remained within the limits of 26° to 28° C during any 24 hour period for the duration of the experiment. Others were kept in a cooler laboratory at 20° to 22° C as controls. These latter temperatures are those at which they are found in abundance in the normal environment (Bovee, 1949). Other bowls were kept in the cooler laboratory, but maintained at 26° to 28° C by setting them in a pan of water in which the temperature was controlled electrically so that in the finger bowls it remained within the limits of 26° to 28° C. Tap water was employed in some bowls as a control series.

After hatching, the larvae were maintained in two ways; either as a brood group, the adults being removed, or isolated individually to separate bowls. Tap water was again employed in some bowls to furnish comparative data. Age as indicated by the instar of development was determined according to the methods of Geisler (1944), using the length and number of the joints in the first antenna as criteria.

Table 1

Embryonic Development in *Hyaella asteca*

26° to 28° C		20° to 22° C	
Brood Number	Hatching Time in Days	Brood Number	Hatching Time in Days
1	7	A	22
2	9	B	17
3	9	C	19
4	8	D	18
5a	7	E	20
5b	7	F	18
6a	7	G	19
6b	7	H	19
7a	6		
7b	7		
8	5		
I	7		
Ia	7		
II	5		
IIa	6		
III	8		
IV	10		
V	6		
VI	8		
VII	8		
VIIa	5		
VIIb	6		

EXPERIMENTAL RESULTS

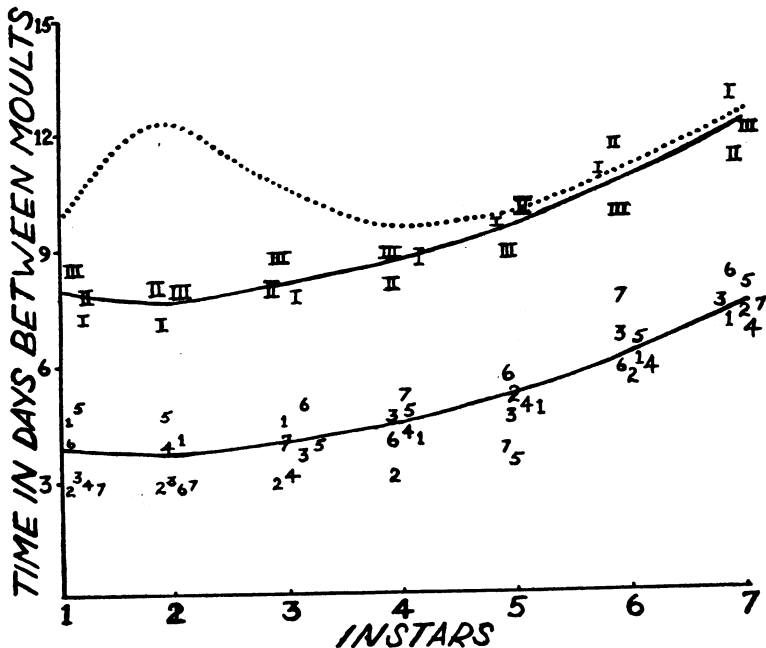
Effect of Temperature on the Rate of Embryonic Development

Ova in the marsupia of females raised in water at 26° to 28° C hatched in from five to ten days, the average hatching time being seven days. Hatching time for those in water at 20° to 22° C varied from 16 to 22 days, the majority hatching in 18 to 19 days (Table 1).

Effect of Temperature on the Rate of Postembryonic Development

Larvae raised in water at temperatures from 26° to 28° C reached nuptial maturity between 26 and 41 days, the average rate of development being about 34 days. Those which were raised at temperatures of 20° to 22° C reached maturity in 43 to 71 days, the most maturing after 60 to 65 days (Figure I).

Figure I
Postembryonic Development in *Hyaella azteca*



Arabic numerals indicate average time in days for instars of brood groups raised at 26° to 28° C. Groups 1, 3, 5 of individuals isolated; groups 2, 4, 6, 7 as brood groups in hatching containers; groups 3, 4, 6, raised in tap water. Roman numerals indicate average time in days for instars of brood groups raised at 20° to 22° C. Group II of isolated individuals; groups I, III as broods in hatching containers; group III in tap water. Dotted line represents Geisler's curve for isolated individuals raised in tap water at 16° to 18° C.

Effect of Temperature on Adult Growth

Adult females, at 26° to 28° C, moulted most frequently in seven or eight days, just after the release of one brood, and just before copulation and oviposition for the next. Males at the same temperatures moulted somewhat more slowly, every eight to ten days in the majority of instances. At 20° to 22° C females moulted most frequently between each 18 to 20 days, and the males between 21 and 25 days (Table 2).

Table 2
Growth in Adult *Hyalessa asteca*

26° to 28° C				20° to 22° C			
Female		Male		Female		Male	
Number	Duration of three instars in days	Number	Duration of three instars in days	Number	Duration of two instars in days	Number	Duration of two instars in days
1	7;7;8	1	9;11;12	A	22;20	A	21;24
2	7;9;8	2	8;10; 9	B	18;19	B	25;23
3	8;9;8	3	12;12;14	C	19;19	C	26;21
4	8;8;8	4	9;11; 9	D	19;21	D	27;24
5	7;8;7	5	10; 9;11	E	22;20	E	19;22
6	9;7;7	6	8; 9; 9	F	20;19	F	22;19
7	7;7;7	7	8;10; 8	G	20;21	G	22;23
8	7;8;7	I	8; 9; 9	H	20;18	H	18;21
I	7;7;7	II	10;11; 9				
II	7;7;8	III	8;12;10				
III	8;8;9	IV	9;11; 8				
IV	10;9;9	V	10; 8;11				
V	7;7;7						
VI	8;8;9						
VII	8;8;7						

Effects of Tap Water and Isolation on Postembryonic Development

No effects were noted which could be attributed to the use of tap water, transfer to other culture conditions, or isolation as opposed to development in the brood group.

DISCUSSION

The failure of some previous investigators to cite the temperatures employed in culturing *Hyalessa asteca* has led to some confusion as to the rate of embryonic and postembryonic development. Embury (1911) gives a time interval of 15 days as the usual length of time for hatching of a single brood during summer months. Jackson (1912) gives 25 days as the hatching period. Gaylor (1922) cites a hatching period of 21 days, with the young being

carried in the marsupium one to three days thereafter. Geisler (1944) gives the first record of temperatures employed, listing hatching as taking place in 21 days at 16° to 18° C, with the brood being retained one to three days in the marsupium. The work herein reported indicates a hatching time of 19 days at 20° to 22° C, the young being released from the brood pouch in one to three days. At 26° to 28° C the hatching period is about seven days, the young being released from the marsupium almost immediately afterward on the same day.

From these data it is apparent that the Q_{10} remains within the usual limits of two to three found in many biological processes.

Geisler (1944) shows slower growth during the first two instars of the larval development than in the third, fourth and fifth. Results herein presented (Figure I) do not substantiate this. As Sexton found in *Gammarus* (1924), growth is more rapid during the first three instars than during the remainder of the larval period. The results which Geisler gives for the first three instars and their retardation do not appear to be due to employment of tap water nor to transfer and isolation of the individual larva, and remain unexplained in this paper.

SUMMARY

1. The embryonic development of *Hyaella azteca* is completed in five to ten days with an average time of seven days at 26° to 28° C; in 18 to 19 days at 20° to 22° C.

2. The postembryonic development of the organism from hatching larva to nuptial adult is completed in 26 to 41 days with an average time of 34 days at 26° to 28° C; and in 43 to 71 days, with an average time of between 60 and 65 days at 20° to 22° C.

3. The first two instars of postembryonic development are found to be shorter than the third, fourth and fifth, contrary to the findings of Geisler (1944). The longer first and second instars reported by Geisler were not brought about by the use of tap water in the culture, nor by isolation and transfer of the hatching larvae to other culture dishes.

4. The adult female completes a growth period in seven to eight days, and the male in eight to ten days at 26° to 28° C. At 20° to 22° C, adult females complete a growth period in 18 to 20 days and adult males in 21 to 26 days.

5. Q_{10} rates for growth and development in *Hyaella azteca* are within the limits of two to three found for many other biological processes.

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